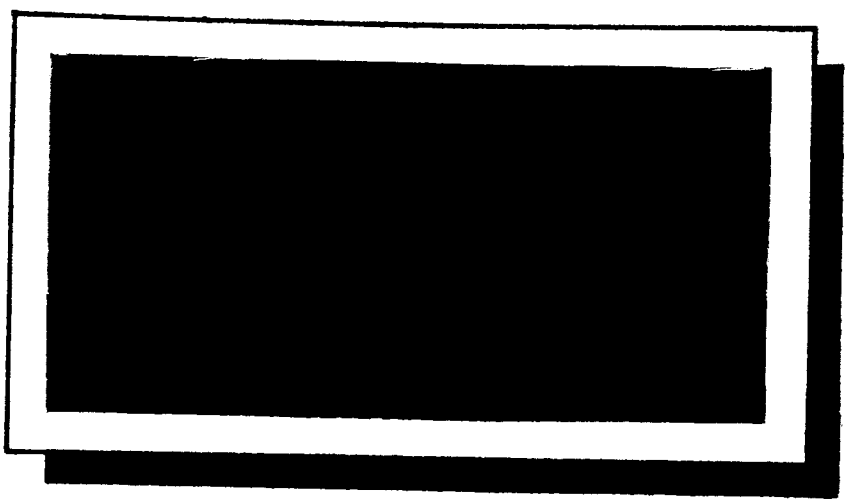

CENTER FOR SPACE RESEARCH
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

NASA Grant NGR-22-009-064

El Campo Solar Radar System

First Semiannual Report

January 1, 1965 to June 30, 1965

DSR Project 4539

PR-4539-1

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EL CAMPO SOLAR RADAR SYSTEM

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To The

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Office of Grants and Research Contracts

Submitted by: J. V. Harrington
Principal Investigator

Radar observations of the sun were made on a daily basis for six days per week, except for a period of seven weeks when Mars observations were made. Sufficient echo energy was received to permit a significant measure of the solar radar cross section for about 70 percent of these experiments. The average cross section during the spring was about 50 percent larger than during 1964. This is attributed to an increase in the average sun spot number. There has been no significant correlation between sun spot number and radar cross section on a daily basis, but the correlation on an average basis for the last four years has been very high. This experimental result should help in understanding the solar reflection process. Furthermore, if the cross section continues to increase with sun spot number, it will become large in comparison with the physical dimension of the corona by the time of sun spot maximum.

Radar experiments were performed on the planet Mars from March 12th to April 7th. One experiment per day was performed for seven days per week. Apparently no measurable echo was received. Receiving bandpasses of 2, 10, 20, and 50 cycles per second were used. Other radar parameters were 500 kilowatts of average transmitted power, a signal integration time equal to the round trip time, and antenna gains of 35db (transmitting and receiving) and 31db (cross-polarized receiving antenna).

In June the outputs of the two cross-polarized antennas were combined in a hybrid circuit in an attempt to separate the solar echo into the two circularly-polarized components. The degree of separation of the components is believed to be reason-

ably good because on two occasions short solar bursts, which were presumed to be circularly polarized, appeared almost entirely in one channel or the other. Preliminary results indicate that on any given day both circularly-polarized components are received, but not always in equal proportions; in some cases as much as two-thirds of the echo is of one circular polarization. These measurements are continuing.

For about one week in June, Crab nebula occultations were observed with the El Campo antenna. On June 14th, when the Crab nebula was very close to the sun, a decrease of about 5db was observed in the normal energy level from the source. The occultation as observed at El Campo in 1962 was somewhat stronger, indicating that the corona was more effective in occulting the source in 1962.

A considerable amount of effort has been spent during this period in modifying the receiving equipment. The bandpass of all receiver stages were broadened so that the overall bandpass was about 200 Kcps. In addition, the bandpass of the tape recording and reproducing amplifiers was broadened and a new tape machine installed. This machine was an old Ampex FR100 that was recently improved and upgraded. This machine allows solar echoes to be recorded with a bandpass of 150 Kcps with 10-inch reels of tape, or with a bandpass of 300 Kcps with 14-inch reels of tape.

These equipment modifications permit a better study of the Doppler spectra of the solar echo. The Doppler spreading of the

solar echo has been observed to vary from 20 to 70 Kcps between the half-power points. Because the receiver bandpass must be broad enough to pass two adjacent spectra, a passband of at least 200 Kcps is required.

Theoretical investigations directed toward a better understanding of the solar reflection process were made throughout this reporting period. It is possible that shock waves moving radially outward in the corona may be responsible for the large fluctuation in cross section and the large Doppler spreading of the solar echo. If so, the radar measurements yield a measure of the velocities of these waves and of the densities at the shock front. Various aspects of this possibility are being investigated. Much narrower antenna beams and increased radar system sensitivity are badly needed to help resolve some of the difficulties in explaining the reflection process.

The solar radar data have continually been analyzed in an attempt to find some systematic variation or some correlation with other measures of solar activity. No strong, consistent correlation has been found for the daily variations but, as has been mentioned, there is a strong correlation between average sun spot number and average cross section. No. strong correlations have been found among the various radar-measured parameters, such as range depth, range centroid, cross section, Doppler shift, Doppler spread, etc.